

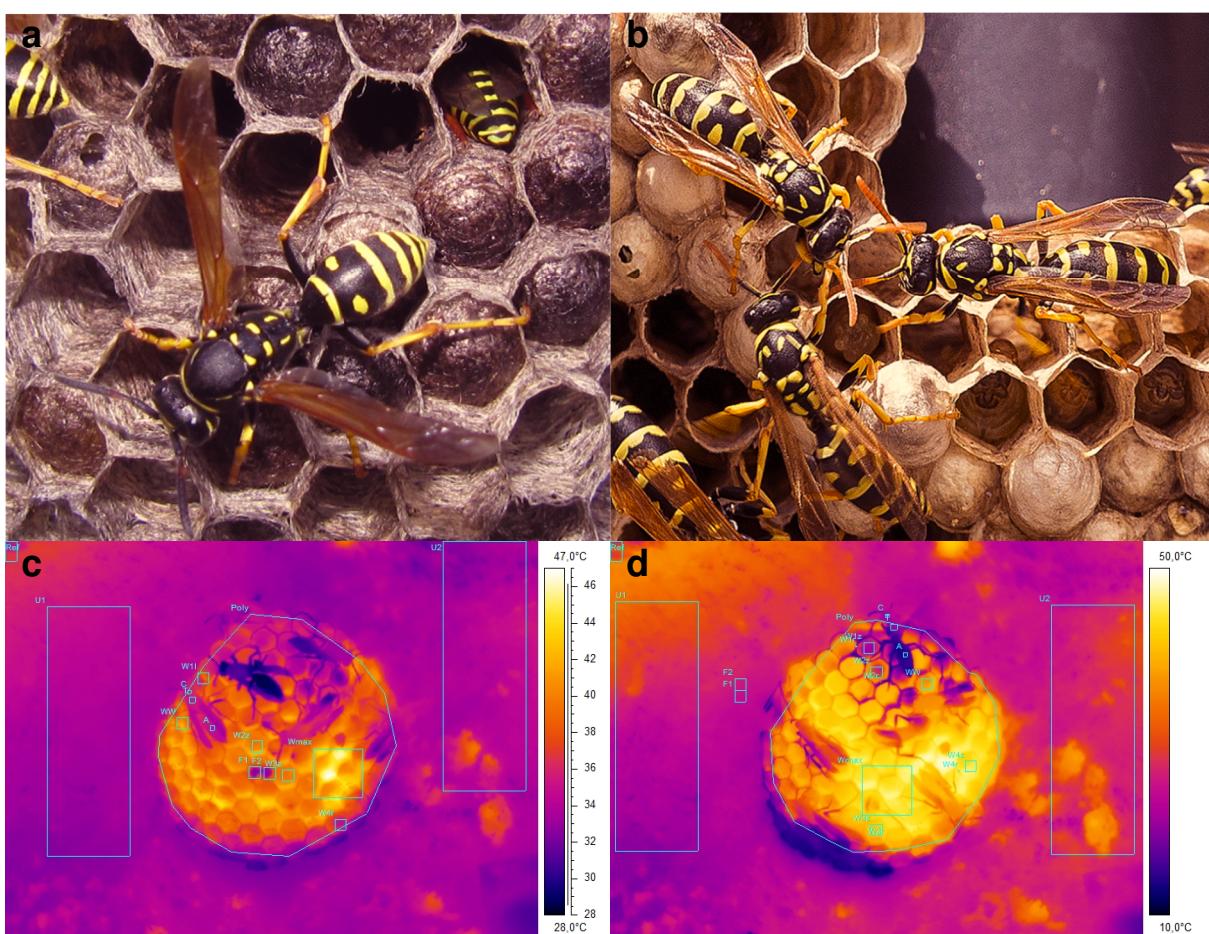
## Supplementary materials

### Effect of climate on strategies of nest and body temperature regulation in paper wasps, *Polistes biglumis* and *Polistes gallicus*

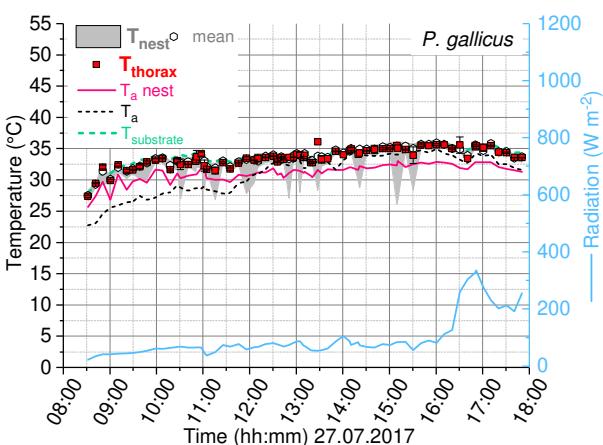
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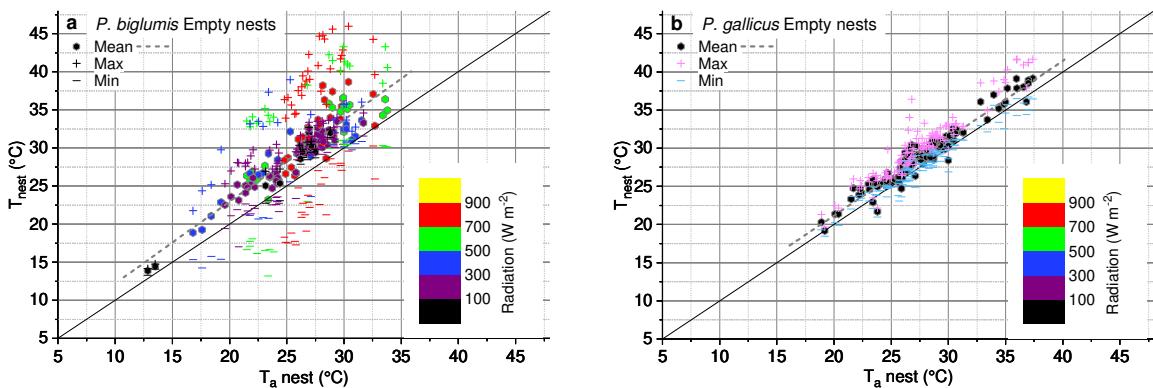
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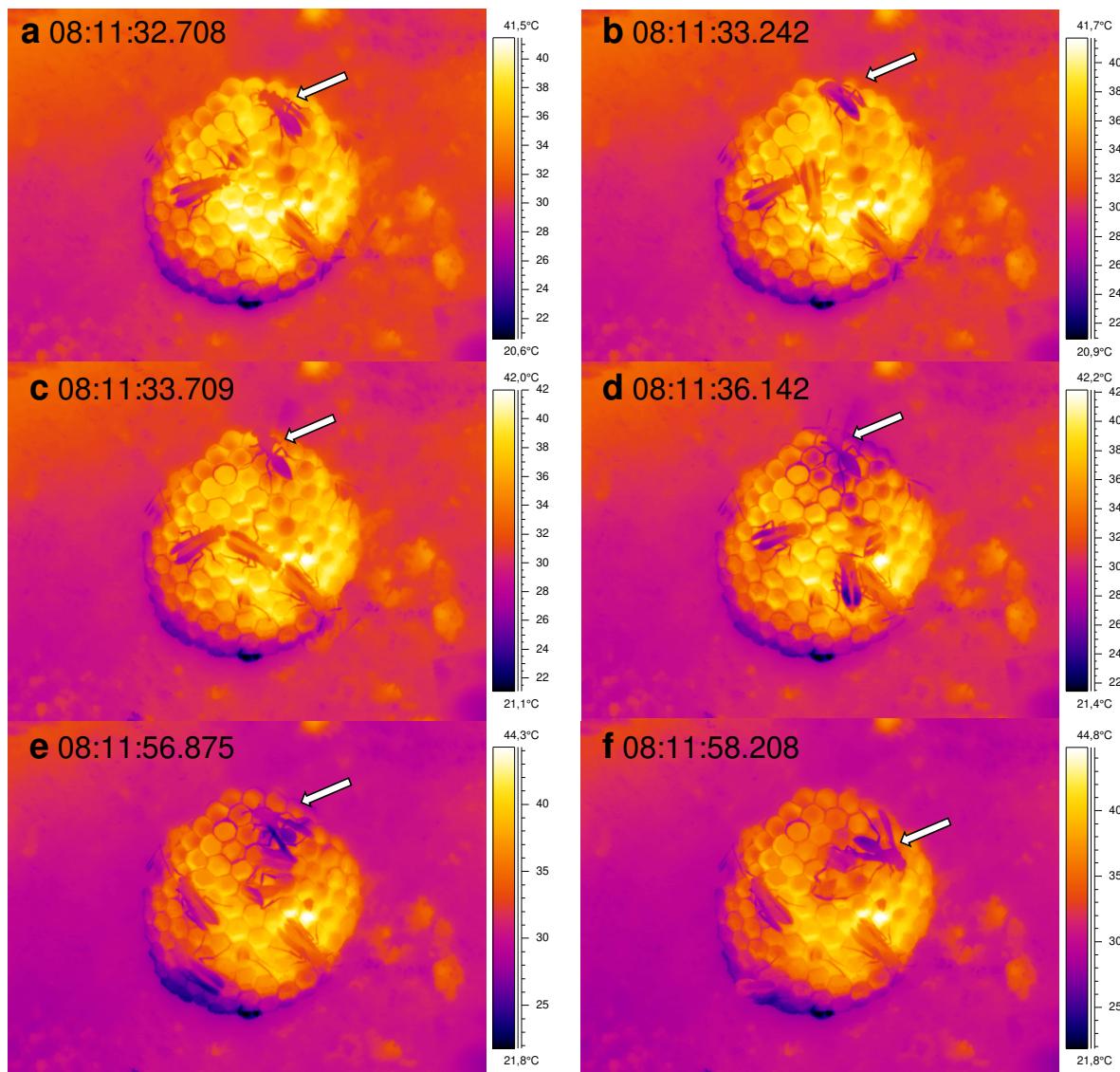
**Figure S1. Wasps and definition of evaluation tools.** (a) *Polistes biglumis*, (b) *Polistes gallicus*. Exemplary positioning and size of measurement tools during: (c) measurement of body and nest temperatures, (d) evaluation of fanning events. Use of measurement tools: (c, d) Poly = whole nest (wasps and cells); Wmax = max. nest temperature; U1, U2 = substrate; C = caput (head), T = thorax, A = abdomen; F1, F2 = water droplets (if present); WW = cell near wasp; Ref = reference radiator (if in picture); (c) W11, W2z, W3z, W4r = cell interior (brood) diagonal from left nest edge to center and right edge; (d) W1r, W2r, W3r, W4r = cell rims close and distant to the fanner, and W1z, W2z, W3z, W4z = cell interiors close and distant to the fanner.



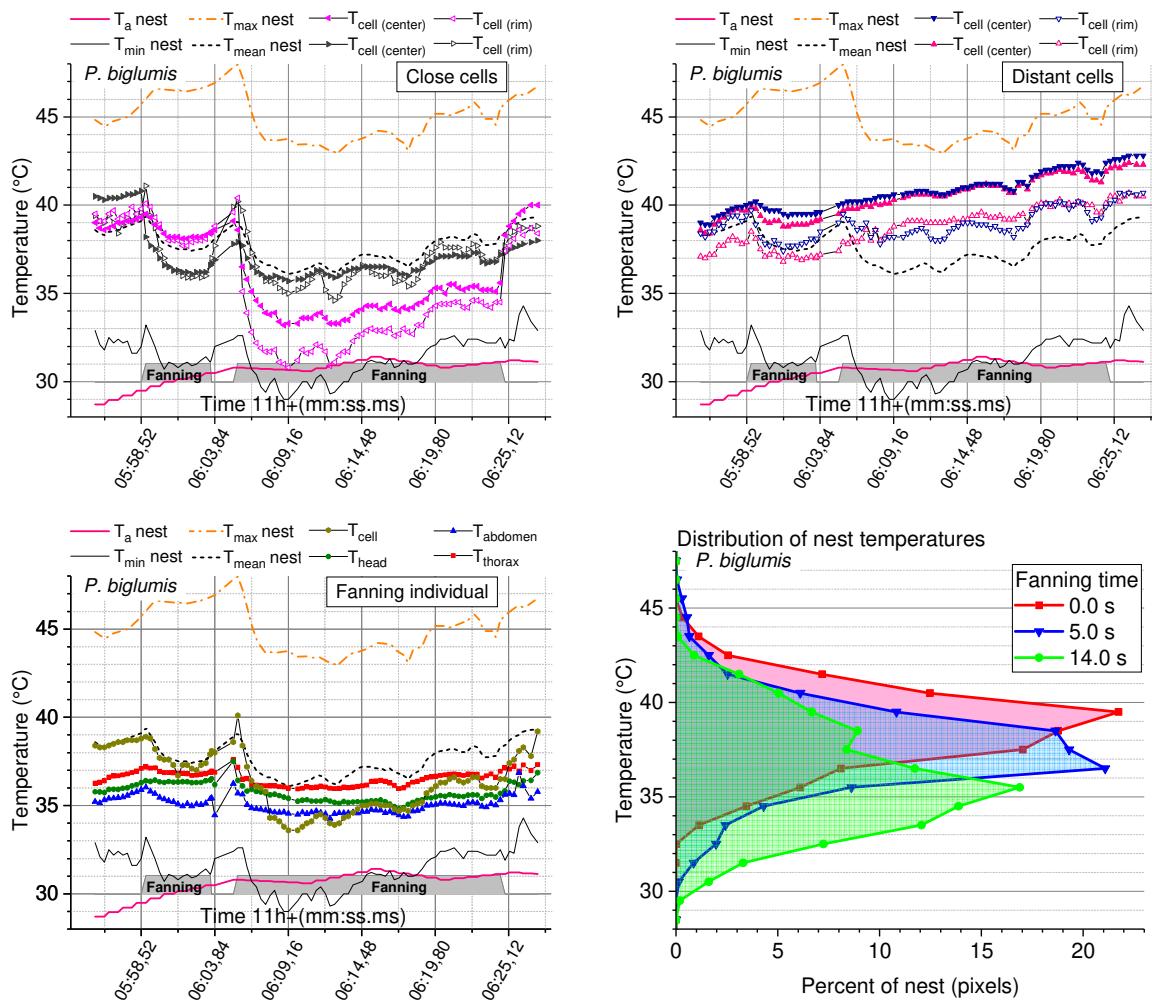
**Figure S2. Example of daily temperature changes of a nest and wasps of *P. gallicus*.**  $T_{\text{thorax}}$  = mean thorax surface temperature of up to five adult individuals per time of measurement; gray ribbon: total range of nest temperatures ( $T_{\text{max}} : T_{\text{min}}$ ) with mean;  $T_{\text{substrate}}$  = temperature beside the nest;  $T_{\text{anest}}$  = ambient air temperature directly at the nest.  $T_a$  = ambient air temperature in shade 1-3m away from the nest; Radiation = global radiation hitting the nest. Fanning was never observed! Time = CEST = UTC+2h.



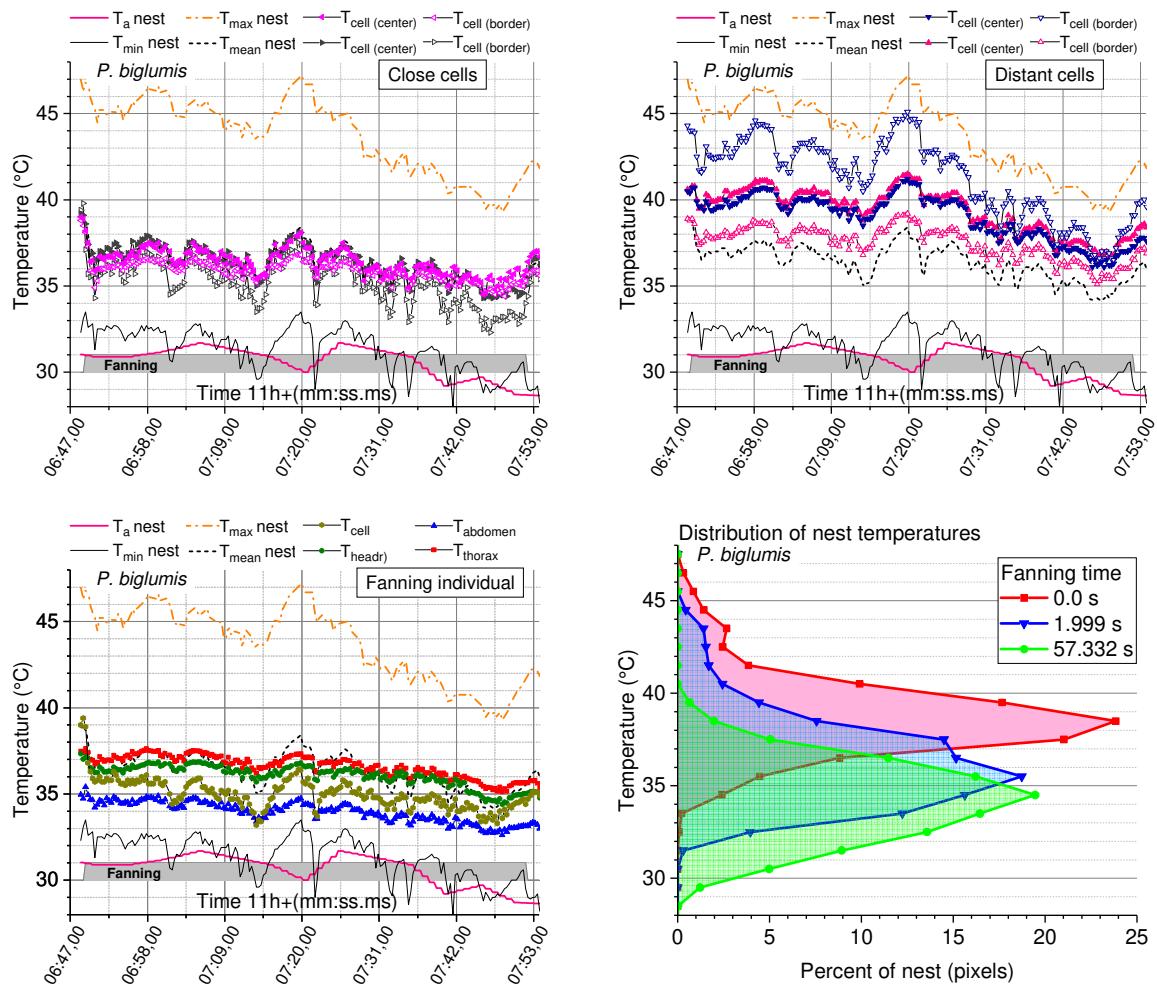
**Figure S3. Temperature of empty nests of *P. biglumis* (a) and *P. gallicus* (b) in dependence on ambient temperature close to the nest ( $T_a$  nest) and global radiation.** Regression lines: a) Mean  $T_{nest} = 1.43936 + 1.07598 \cdot T_{a\ nest}$  (corr.  $R^2 = 0.83528$ ,  $P < 0.0001$ ); b) Mean  $T_{nest} = 0.89998 + 1.01364 \cdot T_{a\ nest}$  (corr.  $R^2 = 0.93876$ ,  $P < 0.0001$ ). Thin diagonal lines = isolines.

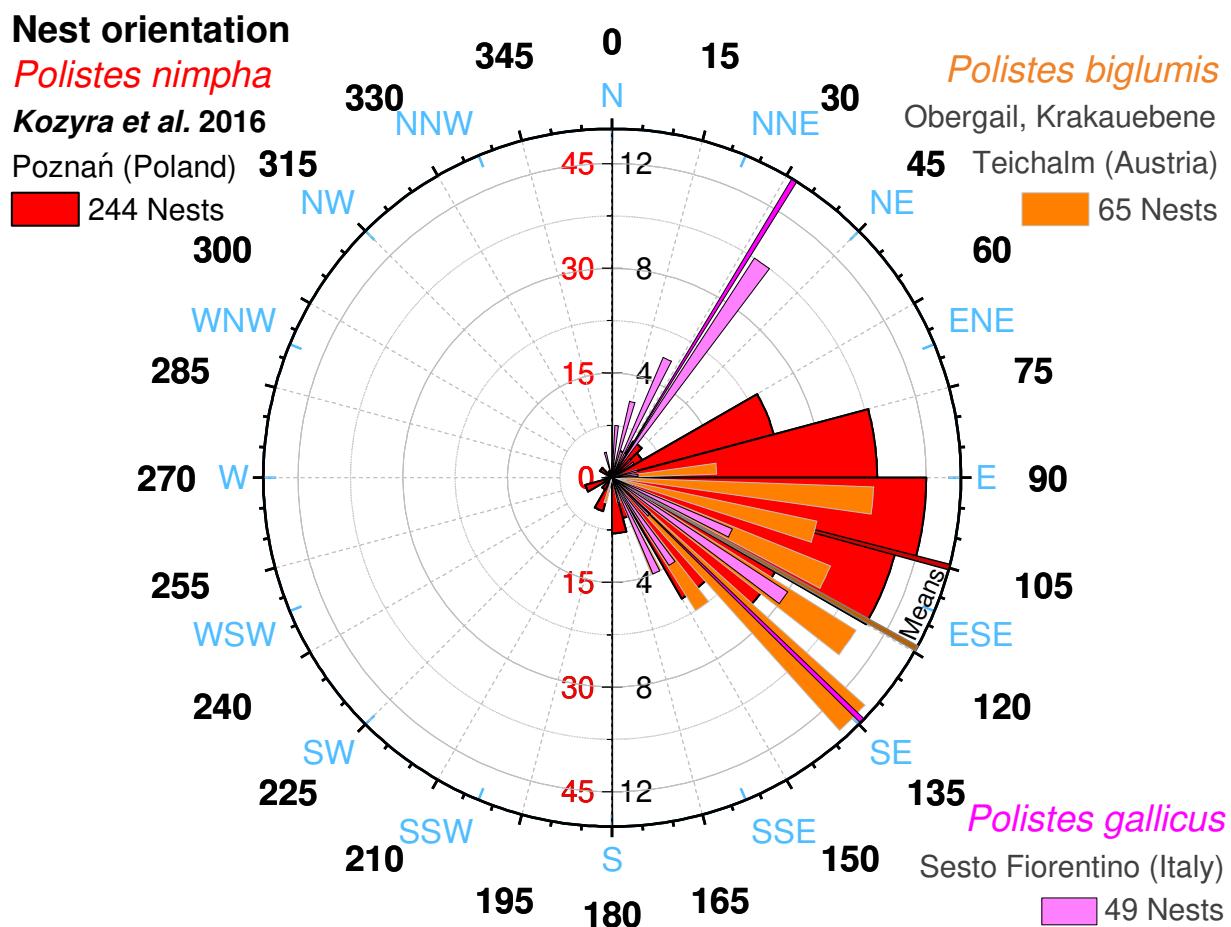


**Figure S4. Behavior of *P. biglumis* during nest cooling.** Top wasp (see arrows): a) sitting on the nest; b) inspecting a cell interior; c, d) fanning, with cooled cells around the faner; e) immediately after stop of fanning; f) the faner walking hectically across the nest. Time = CEST = UTC+2h. See also Video S1 for a thermographic real-time recording of behaviors.

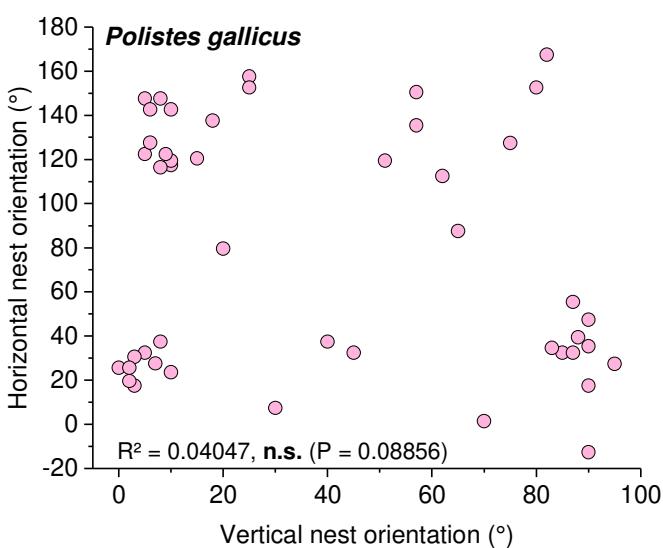


**Figure S5. Cooling effect of fanning in a *Polistes biglumis* nest.** Temperatures measured on cell rims and centers of cells close to and distant of the fanner, and of the body temperature of the fanner. Note the fast temperature increases in close cells after stops of fanning. Also shown are maximum, mean and minimum nest temperature, air temperature close to the nest ( $T_a$ nest), and the change of the total distribution of nest temperatures during different times of fanning (percent of nest at a certain temperature estimated from number of pixels in “Poly” in Fig. S2d). Time = CEST = UTC+2h. Gray bars = duration of fanning. For more samples see Fig. 8 and Fig. S6.

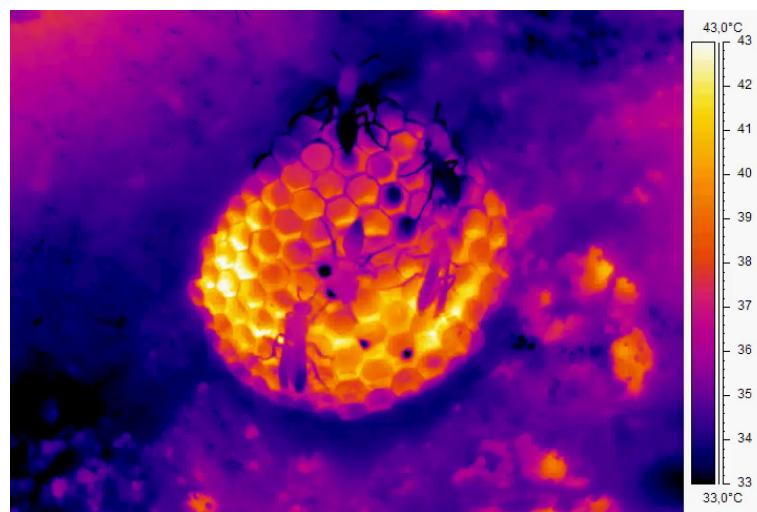




**Figure S7.** Nest orientation of *Polistes biglumis* in Austria and *Polistes gallicus* in Italy (this paper, see Fig. 7; black scale) in comparison to *Polistes nimpha* in Poland (measured by Kozyra et al. [50]; red scale). Mean of *P. nimpha* estimated from angular class means weighted by numbers in classes in Kozyra et al. [50], according to Batschelet [46]. Thin bars = means.



**Figure S8.** Correlation of horizontal and vertical nest orientation in *Polistes gallicus*. Horizontal and vertical orientation measured clockwise from N and downward from horizontal, respectively. See also Fig. 7 and Fig. S7.



**Video S1.** Thermographic real-time recording of nest cooling behaviors of *Polistes biglumis* wasps. FLIR22866\_X2\_32-43-30HZ.m4v

**Table S1. Nest statistics for thermographic measurements in *Polistes biglumis* and *Polistes gallicus*. F2 = foundress nest with 1 egg.**

Species	Location	Date (d m y)	Nest	N <sub>cells</sub>	N <sub>wasps</sub>	Eggs	Larvae	Pupae
<i>P. biglumis</i>	Obergail	20-21 Aug 2010	N1	90	12	✓	✓	✓
		20-21 Aug 2010	N2	45	8	✓	✓	✓
		20-21 Aug 2010	N3	36	8	-	✓	✓
	Obergail	16-18 Jul 2017	W4	95	9	✓	✓	✓
		15-16, 19-20 Jul 2017	W5	99	8	✓	✓	✓
		21 Jul 2017	S4	48	4	✓	✓	✓
	Obergail	28-30 Apr 2018	F2	18	1	✓	-	-
Mean				61.6	7.1			
SD				32.50	3.58			
N				7	7			
<i>P. gallicus</i>	Sesto Fiorentino	4-5 Aug 2015	N1	162	6	✓	✓	-
		4-5 Aug 2015	N2	19	4	✓	✓	-
	Sesto Fiorentino	26 Jul 2017	N1	180	21	✓	✓	✓
		27 Jul 2017	N2	35	8	-	✓	✓
		31 Jul, 1 Aug 2017	N3	381	64	✓	✓	✓
		28 Jul 2017	N4	23	4	✓	✓	✓
		12-13 Jun 2018	N1	136	14	✓	✓	✓
		13 Jun 2018	N2	28	2	✓	✓	✓
		14 Jun 2018	N3	30	1	✓	✓	✓
		15 Jun 2018	N4	23	2	-	✓	✓
	Mean			101.7	12.6			
	SD			117.00	19.11			
	N			10	10			

**Table S2. Regression statistics for Fig. 6.** Regressions were calculated for shaded conditions (Radiation = 0–100 W/m<sup>2</sup>) and sunshine (Radiation > 100 W/m<sup>2</sup>).

<i>Polistes biglumis</i>			<i>Polistes gallicus</i>		
<b>Fig 6a: 0-100 W/m<sup>2</sup></b>			<b>Fig 6b: 0-100 W/m<sup>2</sup></b>		
Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$		Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	33.30038	N	a	43.1248
1182	xc	17.30062	1849	xc	25.64835
R <sup>2</sup> (adj. for df)	d	2.66866	R <sup>2</sup> (adj. for df)	d	4.04607
0.9524	k	0.19444	0.96239	k	0.16561
df	F value	P	df	F value	P
4	50655.67857	0	4	415224.40331	0
<b>Fig 6a: &gt;100 W/m<sup>2</sup></b>			<b>Fig 6b: &gt;100 W/m<sup>2</sup></b>		
Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$		Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	39.78362	N	a	46.88662
604	xc	-1.72616	459	xc	25.02548
R <sup>2</sup> (adj. for df)	d	5.51901E-6	R <sup>2</sup> (adj. for df)	d	3.13224
0.3951	k	0.06693	0.88466	k	0.13799
df	F value	P	df	F value	P
4	18262.72032	0	4	44034.18034	0
<b>Fig 6c: 0-100 W/m<sup>2</sup></b>			<b>Fig 6d: 0-100 W/m<sup>2</sup></b>		
Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$		Function	$y = a / (1 + b * \exp(-k * x))$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	31.6623	N	a	37.25805
446	xc	19.43795	372	b	26.71312
R <sup>2</sup> (adj. for df)	d	5.12031	R <sup>2</sup> (adj. for df)	k	0.17399
0.94268	k	0.34228	0.7713	df	P
df	F value	P	3	47060.11861	0
4	18552.70996	0			
<b>Fig 6c: &gt;100 W/m<sup>2</sup></b>			<b>Fig 6d: &gt;100 W/m<sup>2</sup></b>		
Function	$y = a / (1 + b * \exp(-k * x))$		Function	$y = a / (1 + b * \exp(-k * x))$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	37.23623	N	a	39.78673
444	b	0.78158	116	b	19.47444
R <sup>2</sup> (adj. for df)	k	0.07687	R <sup>2</sup> (adj. for df)	k	0.15554
0.07038			0.46564	df	P
df	F value	P	3	16852.80637	0
3	9864.88997	0			
<b>Fig 6e: 0-100 W/m<sup>2</sup></b>			<b>Fig 6f: 0-100 W/m<sup>2</sup></b>		
Function	$y = a + b * x$		Function	$y = a * (1 + (d-1) * \exp(-k * (x-xc)))^{(1/(1-d))}$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	-0.65503	N	a	37.01784
28	b	1.0877	474	xc	6.88713
R <sup>2</sup> (adj. for df)			R <sup>2</sup> (adj. for df)	d	8.0175E-8
0.54571			0.01119	k	0.07827
df	F value	P	df	F value	P
1	33.43339	4.32604E-6	4	161615.12461	0
<b>Fig 6e: &gt;100 W/m<sup>2</sup></b>			<b>Fig 6f: &gt;100 W/m<sup>2</sup></b>		
Function	$y = a / (1 + b * \exp(-k * x))$		Function	$y = a + b * x$	
<b>Parameters</b>	<b>Value</b>		<b>Parameters</b>	<b>Value</b>	
N	a	33.94687	N	a	33.00219
565	b	25.43604	1723	b	0.04674
R <sup>2</sup> (adj. for df)	k	0.2732	R <sup>2</sup> (adj. for df)		
0.3134			0.4697	df	
df	F value	P	1	5.34144	P
3	34170.10356	0			0.02125

**Table S3. Multiple linear model regressions of wasp body, cell, brood, water and nest temperatures in relation to air temperature at the nest ( $T_{\text{anest}}$ ) and radiation.  $T_{\text{cell}}(\text{wasp})$  = cell temperature close to the measured wasps;  $T_{\text{pupae}}$  = closed cells (pupae and praepupae).**

<i>Polistes biglumis</i>				<i>Polistes gallicus</i>			
<b>Model:</b> $T_{\text{thorax}} = 0.663091 + 1.05429 \cdot T_{\text{anest}} + 0.0073271 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{thorax}} = 4.41488 + 0.897436 \cdot T_{\text{anest}} + 0.0038995 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 0.663091	T <sub>anest</sub> 1.05429	Radiation 0.0073271	N 1798	<b>Parameters:</b> Constant 4.41488	T <sub>anest</sub> 0.897436	Radiation 0.0038995	N 2488
<b>P:</b> 0.0171	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 87.9143	<b>F quotient</b> 6536.9	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 93.7527	<b>P</b> 18662.18
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{head}} = 0.801792 + 1.04687 \cdot T_{\text{anest}} + 0.00674879 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{head}} = 4.98728 + 0.874044 \cdot T_{\text{anest}} + 0.00342588 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 0.801792	T <sub>anest</sub> 1.04687	Radiation 0.00674879	N 1786	<b>Parameters:</b> Constant 4.98728	T <sub>anest</sub> 0.874044	Radiation 0.00342588	N 2480
<b>P:</b> 0.0036	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 87.6588	<b>F quotient</b> 6340.36	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 93.0003	<b>P</b> 16469.44
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{abdomen}} = 0.0755071 + 1.0775 \cdot T_{\text{anest}} + 0.00538768 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{abdomen}} = 4.09628 + 0.909778 \cdot T_{\text{anest}} + 0.00281136 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 0.0755071	T <sub>anest</sub> 1.0775	Radiation 0.00538768	N 1796	<b>Parameters:</b> Constant 4.09628	T <sub>anest</sub> 0.909778	Radiation 0.00281136	N 2483
<b>P:</b> 0.7829	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 87.2386	<b>F quotient</b> 6136.43	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 93.763	<b>P</b> 18657.46
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{cell}}(\text{wasp}) = 1.56651 + 1.05861 \cdot T_{\text{anest}} + 0.00760077 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{cell}}(\text{wasp}) = 9.69614 + 0.70718 \cdot T_{\text{anest}} + 0.00464809 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 1.56651	T <sub>anest</sub> 1.05861	Radiation 0.00760077	N 1798	<b>Parameters:</b> Constant 9.69614	T <sub>anest</sub> 0.70718	Radiation 0.00464809	N 2728
<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 83.8733	<b>F quotient</b> 4673.99	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 81.5032	<b>P</b> 6009.05
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{egg}} = 4.73166 + 0.733708 \cdot T_{\text{anest}} + 0.0115997 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{egg}} = 47.3688 - 0.168815 \cdot T_{\text{anest}} - 0.0732512 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 4.73166	T <sub>anest</sub> 0.733708	Radiation 0.0115997	N 133	<b>Parameters:</b> Constant 47.3688	T <sub>anest</sub> -0.168815	Radiation -0.0732512	N 16
<b>P:</b> 0.0012	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 86.0359	<b>F quotient</b> 407.64	<b>P:</b> 0.0008	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 0	<b>P</b> 0.4459
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{larvae}} = 4.28143 + 0.942742 \cdot T_{\text{anest}} + 0.00664672 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{larvae}} = 17.8605 + 0.474338 \cdot T_{\text{anest}} + 0.00487993 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 4.28143	T <sub>anest</sub> 0.942742	Radiation 0.00664672	N 400	<b>Parameters:</b> Constant 17.8605	T <sub>anest</sub> 0.474338	Radiation 0.00487993	N 274
<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 77.8072	<b>F quotient</b> 700.44	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 62.8895	<b>P</b> 232.32
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{pupae}} = 3.44504 + 0.940025 \cdot T_{\text{anest}} + 0.00528399 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{pupae}} = 17.8605 + 0.713172 \cdot T_{\text{anest}} + 0.00556407 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 3.44504	T <sub>anest</sub> 0.940025	Radiation 0.00528399	N 397	<b>Parameters:</b> Constant 9.47043	T <sub>anest</sub> 0.713172	Radiation 0.00556407	N 973
<b>P:</b> 0.0003	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 74.4985	<b>F quotient</b> 579.42	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 78.5835	<b>P</b> 1784.28
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{water}} = 24.0442 + 0.214143 \cdot T_{\text{anest}} + 0.0038388 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{water}} = 22.2658 + 0.293081 \cdot T_{\text{anest}} + 0.00251734 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 24.0442	T <sub>anest</sub> 0.214143	Radiation 0.0038388	N 612	<b>Parameters:</b> Constant 22.2658	T <sub>anest</sub> 0.293081	Radiation 0.00251734	N 552
<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 28.1329	<b>F quotient</b> 120.59	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 40.8158	<b>P</b> 191
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{nest(max)}} = 5.6148 + 0.920164 \cdot T_{\text{anest}} + 0.0148126 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{nest(max)}} = 2.73006 + 0.976603 \cdot T_{\text{anest}} + 0.0101429 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 5.6148	T <sub>anest</sub> 0.920164	Radiation 0.0148126	N 1888	<b>Parameters:</b> Constant 2.73006	T <sub>anest</sub> 0.976603	Radiation 0.0101429	N 2736
<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 82.5138	<b>F quotient</b> 4453.18	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 91.5042	<b>P</b> 14729.72
<b>ANOVA:</b>				<b>ANOVA:</b>			
<b>Model:</b> $T_{\text{nest(mean)}} = 2.38935 + 1.0085 \cdot T_{\text{anest}} + 0.00696722 \cdot \text{Radiation}$	<b>Model:</b> $T_{\text{nest(mean)}} = 6.58421 + 0.821208 \cdot T_{\text{anest}} + 0.00265919 \cdot \text{Radiation}$						
<b>Parameters:</b> Constant 2.38935	T <sub>anest</sub> 1.0085	Radiation 0.00696722	N 2524	<b>Parameters:</b> Constant 6.58421	T <sub>anest</sub> 0.821208	Radiation 0.00265919	N 2980
<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 82.3024	<b>F quotient</b> 5867.6	<b>P:</b> 0	<b>df</b> 2	<b>R</b> <sup>2</sup> (%., adj. for df) 83.5367	<b>P</b> 7558.88
<b>ANOVA:</b>				<b>ANOVA:</b>			

**Table S4.** Multiple linear model regressions of wasp body, cell, brood, water and nest temperatures in relation to air temperature at the nest ( $T_{\text{anest}}$ ), radiation and substrate temperature ( $T_{\text{substrate}}$ ).  $T_{\text{cell(wasp)}}$  = cell temperature close to the measured wasps;  $T_{\text{pupae}}$  = closed cells (pupae and praepupae).

<i>Polistes biglumis</i>						<i>Polistes gallicus</i>					
<b>Model:</b> $T_{\text{thorax}} = -2.23641 + 0.69335 \cdot T_{\text{anest}} + 0.00616842 \cdot \text{Radiation} + 0.420965 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{thorax}} = 5.00368 + 0.559154 \cdot T_{\text{anest}} + 0.00420989 \cdot \text{Radiation} + 0.291242 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-2.23641	0.69335	0.00616842	0.420965	1798		5.00368	0.559154	0.00420989	0.291242	2488	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	89.1011	4897.99	0			3	95.9768	19777.61	0		
<b>Model:</b> $T_{\text{head}} = -2.1428 + 0.678948 \cdot T_{\text{anest}} + 0.0055964 \cdot \text{Radiation} + 0.428729 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{head}} = 5.59942 + 0.521981 \cdot T_{\text{anest}} + 0.00375059 \cdot \text{Radiation} + 0.303086 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-2.1428	0.678948	0.0055964	0.428729	1786		5.59942	0.521981	0.00375059	0.303086	2480	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	88.9342	4782.94	0			3	95.5469	17730.9	0		
<b>Model:</b> $T_{\text{abdomen}} = -2.96496 + 0.699074 \cdot T_{\text{anest}} + 0.00417238 \cdot \text{Radiation} + 0.441451 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{abdomen}} = 4.7184 + 0.549191 \cdot T_{\text{anest}} + 0.00314149 \cdot \text{Radiation} + 0.310577 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-2.96496	0.699074	0.00417238	0.441451	1796		Apr.84	0.549191	0.00314149	0.310577	2483	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	88.6591	4678.56	0			3	96.2918	21484.48	0		
<b>Model:</b> $T_{\text{cell(wasp)}} = -1.69964 + 0.652027 \cdot T_{\text{anest}} + 0.00629557 \cdot \text{Radiation} + 0.474197 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{cell(wasp)}} = 10.7287 + 0.272718 \cdot T_{\text{anest}} + 0.00517888 \cdot \text{Radiation} + 0.367007 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-1.69964	0.652027	0.00629557	0.474197	1798		Okt.87	0.272718	0.00517888	0.367007	2727	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	85.275	3469.92	0			3	86.096	5627.64	0		
<b>Model:</b> $T_{\text{egg}} = 2.74507 + 0.324319 \cdot T_{\text{anest}} + 0.00697478 \cdot \text{Radiation} + 0.513289 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{egg}} = 36.8406 - 0.975044 \cdot T_{\text{anest}} + 0.357492 \cdot \text{Radiation} + 0.423053 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
2.74507	0.324319	0.00697478	0.513289	133		36.8406	-0.975044	0.357492	0.423053	8	
<b>P:</b>	0.0505	0.0064	0	0		<b>P:</b>	0.0488	0.0558	0.0679	0.137	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	87.9941	323.49	0			3	51.1285	Mär.44	0.1318		
<b>Model:</b> $T_{\text{larvae}} = 0.296351 + 0.601333 \cdot T_{\text{anest}} + 0.00455124 \cdot \text{Radiation} + 0.464692 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{larvae}} = 17.861 + 0.100866 \cdot T_{\text{anest}} + 0.00428128 \cdot \text{Radiation} + 0.336978 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
0.296351	0.601333	0.00455124	0.464692	400		17.861	0.100866	0.00428128	0.336978	273	
<b>P:</b>	0.7754	0	0	0		<b>P:</b>	0	0.0111	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	80.0755	535.52	0			3	74.4294	264.91	0		
<b>Model:</b> $T_{\text{pupae}} = -0.975249 + 0.545477 \cdot T_{\text{anest}} + 0.00302162 \cdot \text{Radiation} + 0.527851 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{pupae}} = 10.0351 + 0.087647 \cdot T_{\text{anest}} + 0.00694214 \cdot \text{Radiation} + 0.552736 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-0.975249	0.545477	0.00302162	0.527851	397		10.0351	0.087647	0.00694214	0.552736	973	
<b>P:</b>	0.3545	0	0.0001	0		<b>P:</b>	0	0.0069	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	77.6794	460.38	0			3	85.1314	1856.09	0		
<b>Model:</b> $T_{\text{water}} = 20.282 + 0.184558 \cdot T_{\text{anest}} + 0.00239761 \cdot \text{Radiation} + 0.174133 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{water}} = 18.8619 - 0.0278721 \cdot T_{\text{anest}} + 0.00165691 \cdot \text{Radiation} + 0.38456 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
20.282	0.184558	0.00239761	0.174133	612		18.8619	-0.0278721	0.00165691	0.38456	552	
<b>P:</b>	0	0	0.0001	0.0002		<b>P:</b>	0	0.4304	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	29.608	86.67	0			3	49.9812	184.53	0		
<b>Model:</b> $T_{\text{nest(max)}} = 2.19849 + 0.468458 \cdot T_{\text{anest}} + 0.0134079 \cdot \text{Radiation} + 0.520648 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{nest(max)}} = 3.83154 + 0.485144 \cdot T_{\text{anest}} + 0.0107037 \cdot \text{Radiation} + 0.41755 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
2.19849	0.468458	0.0134079	0.520648	1888		3.83154	0.485144	0.0107037	0.41755	2727	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	83.8313	3262.24	0			3	94.7725	16474.91	0		
<b>Model:</b> $T_{\text{nest(mean)}} = -2.14936 + 0.510637 \cdot T_{\text{anest}} + 0.00475538 \cdot \text{Radiation} + 0.611022 \cdot T_{\text{substrate}}$						<b>Model:</b> $T_{\text{nest(mean)}} = 8.01929 + 0.0986386 \cdot T_{\text{anest}} + 0.00318776 \cdot \text{Radiation} + 0.620503 \cdot T_{\text{substrate}}$					
<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N		<b>Parameters:</b> Constant	$T_{\text{anest}}$	Radiation	$T_{\text{substrate}}$	N	
-2.14936	0.510637	0.00475538	0.611022	2524		8.01929	0.0986386	0.00318776	0.620503	2971	
<b>P:</b>	0	0	0	0		<b>P:</b>	0	0	0	0	
<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>		<b>ANOVA:</b>	<b>df</b>	<b>R<sup>2</sup></b> (%. adj. for df)	<b>F quotient</b>	<b>P</b>	
3	85.1029	4805.38	0			3	93.6939	14710.16	0		

**Table S5. Multifactor ANOVA comparison between species.** Mean T = mean temperatures after compensation for the effects of covariables.  $T_{\text{cell(wasp)}}$  = cell temperature close to the measured wasps;  $T_{\text{pupae}}$  = closed cells (pupae and praepupae).

Dependent variable: $T_{\text{thorax}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	4286	4.06	0.0439		<i>Mean T:</i> N: 28.7884 1798	29.0406 2488
	Covariables:						
	$T_{\text{anest}}$		1998.52	0			
	Radiation		2082.41	0			
	$T_{\text{substrate}}$		490.05	0			
Dependent variable: $T_{\text{head}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	4266	7.72	0.0055		<i>Mean T:</i> N: 28.5366 1786	28.8848 2480
	Covariables:						
	$T_{\text{anest}}$		1848.18	0			
	Radiation		1807.63	0			
	$T_{\text{substrate}}$		506.51	0			
Dependent variable: $T_{\text{abdomen}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	4279	14.67	0.0001		<i>Mean T:</i> N: 28.396 1796	28.8635 2483
	Covariables:						
	$T_{\text{anest}}$		2088.27	0			
	Radiation		1305.22	0			
	$T_{\text{substrate}}$		574.64	0			
Dependent variable: $T_{\text{cell(wasp)}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	4526	13.8	0.0002		<i>Mean T:</i> N: 28.5837 1798	29.1748 2728
	Covariables:						
	$T_{\text{anest}}$		702.46	0			
	Radiation		1842.3	0			
	$T_{\text{substrate}}$		329.07	0			
Dependent variable: $T_{\text{empty cells}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	590	0.81	<b>0.3676</b>		<i>Mean T:</i> N: 30.6195 346	30.1395 244
	Covariables:						
	$T_{\text{anest}}$		49.57	0			
	Radiation		175.66	0			
	$T_{\text{substrate}}$		31.29	0			
Dependent variable: $T_{\text{eggs}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	149	0.02	<b>0.8922</b>		<i>Mean T:</i> N: 25.0141 133	24.7202 16
	Covariables:						
	$T_{\text{anest}}$		7.97	0.0054			
	Radiation		33.52	0			
	$T_{\text{substrate}}$		21.2	0			
Dependent variable: $T_{\text{larvae}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	674	0.69	<b>0.4046</b>		<i>Mean T:</i> N: 30.7568 400	30.3033 274
	Covariables:						
	$T_{\text{anest}}$		97.92	0			
	Radiation		213.01	0			
	$T_{\text{substrate}}$		44.92	0			
Dependent variable: $T_{\text{pupae}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	1370	55.76	0		<i>Mean T:</i> N: 28.2522 397	30.1069 973
	Covariables:						
	$T_{\text{anest}}$		82.33	0			
	Radiation		380.27	0			
	$T_{\text{substrate}}$		224.98	0			
Dependent variable: $T_{\text{water}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	1164	6.78	0.0092		<i>Mean T:</i> N: 33.1658 612	32.3025 552
	Covariables:						
	$T_{\text{anest}}$		33.4	0			
	Radiation		55.87	0			
	$T_{\text{substrate}}$		61.74	0			
Dependent variable: $T_{\text{nest(max)}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	4624	54.12	0		<i>Mean T:</i> N: 32.0823 1888	30.9016 2736
	Covariables:						
	$T_{\text{anest}}$		666.97	0			
	Radiation		4304.59	0			
	$T_{\text{substrate}}$		710.92	0			
Dependent variable: $T_{\text{nest(mean)}}$	Factors:	N	F-Quotient	P		<i>P. biglumis</i>	<i>P. gallicus</i>
	Species	5504	2.89	<b>0.0892</b>		<i>Mean T:</i> N: 29.1406 2524	29.374 2980
	Covariables:						
	$T_{\text{anest}}$		484.12	0			
	Radiation		1703.15	0			
	$T_{\text{substrate}}$		1409.3	0			